THURSDAY, MAY 4, 1916.

THERMODYNAMIC AND KINETIC THEORIES.

(1) *Statistical Theory of Energy and Matter.* By Dr. T. Wereide. Pp. xvi+170. (Kristiania: Gyldendalske Boghandel Nordisk Forlag, 1915.) No price.

(2) *Eight Lectures on Theoretical Physics delivered at Columbia University in* 1909. By Dr. Max Planck; translated by Prof. A. P. Wills. Pp. xi+130. (New York: Columbia University Press, 1915.) Price 1 dollar.

IN the development of modern theoretical physics two lines of inquiry have played an important part. One has been the attempt to deduce reversible physical phenomena from the inequalities of irreversible thermodynamics; the other the endeavour to reconcile irreversible phenomena with the equations of reversible dynamics. Between the two we have arrived at a more or less satisfactory representation of many phenomena of an essentially statical character. Progress has, however, been somewhat retarded since the death of Boltzmann, nor can we forget Lord Kelvin's healthy criticisms and the steadying influence in times gone by of representatives of the old rigorous school of Cambridge philosophy, such as Watson and Burbury.

(1) Dr. Thornstein Wereide's introduction to the statistical theory of energy and matter is calculated to revive interest in these oft-debated problems. The author will scarcely be surprised at our statement that the book does not appear to throw light on any new facts or contain any original work of a fundamental character, but the method of treatment and of exposition is novel in many respects, and the account of Soret's phenomena describes experimental researches the results of which appear to be inconsistent with preconceived hypotheses.

The book is divided into two sections. The first is occupied exclusively with the deduction of the fundamental formulæ of statistical mechanics, and occupies practically the first sixty-four pages, since "Maxwell's distribution of velocities," though placed at the beginning of section ii., really belongs to the first section. The second section describes the applications of the theory to various physical phenomena, including specific heat, equilibrium, phenomena associated with change of state, diffusion, the phase rule, magnetism, radiation, and finally the quantum hypothesis of Planck.

A study of the first section might with advantage be supplemented by reading some of the older classical treatises and papers on the kinetic theory, in which the application of Lagrange's and Hamilton's equations of motion is developed in greater detail. For example, the proof of Lagrange's equations is unsatisfactory, and the discussion in § 9 cannot be regarded as constituting a rigorous *proof* of the stated property that the density of probability of a system in statistical equilibrium is a function of the energy alone. To understand this property thoroughly it is necessary to read the older proofs based on the formulation of the Jacobian determinant of the co-ordinates and momenta of the system.

Irreversibility is postulated in the following argument:—

"Let us suppose that the system at a given moment passes through a number of elements, W, that are not all possible. It is then very improbable that the system will cease frequenting the elements hitherto frequented, and never visit them any more. On the other hand, it is very probable that the system, as time passes, will take up more and more elements into its circuit provided that an entrance into these elements is possible."

This assumed, the author deduces that—

"A system that is left to itself will change in such a manner that the density of probability for a given state will either remain constant or decrease. The density of probability can never increase."

And he goes on further to restate the hypothesis as follows:—

"A system that is left to itself will move in such a manner that the number of configurations either is constant or it increases. The number of configurations can never decrease."

Unfortunately this assumption is the exact opposite of the second law of thermodynamics, which states that in an isolated system the number of configurations which it is possible for a system to assume is always decreasing. In this case the decrease takes place by the gradual wiping out, one by one, of the possible configurations for which the sum of the potential and kinetic energies of visible motions is a maximum.

The quantum hypothesis is, of course, an innovation since the days of the classical treatises on the kinetic theory. What the author of this book says in commenting on this theory is sensible enough, namely, that by means of this hypothesis Planck has explained phenomena that others have failed to explain, and it cannot, therefore, be rejected merely because it fails to account for everything.

Dr. Wereide thinks that the best way of throwing light on this question is by a renewed study of the trustworthiness or otherwise of statistical methods.

Now it so happens that the writer of this review, before abandoning gases in favour of aeroplanes, endeavoured to direct attention to a method of investigation in statistical mechanics under the title of "Energy Accelerations." The essential feature of this method was to study the *second* differential coefficients with respect to the time of the squares and products of the velocities of a statistical dynamical system, these determining accelerations of energy which would not be altered in sign by reversing the motions, just as the second differential coefficients of the co-ordinates determine the accelerations of the masses. Unfortunately this suggestion does not appear to

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have been taken up. Yet it *does* lead to conclusions which impose serious limitations on the conditions under which statistical energy equilibrium is possible. It shows that a given distribution of density of the co-ordinates of a system in statistical equilibrium can only possess a definite amount of kinetic energy; that such a state of equilibrium may be stable or unstable; that certain distributions are incompatible with statistical energy equilibrium because they would give a negative value for the squares of the velocity compounds, and in particular that statistical energy equilibrium, such as occurs in the molecules of a gas, is impossible in a system of bodies attracting each other according to the Newtonian law of gravitation. It is quite likely that such an investigation if continued would lead to the deduction of a system the energy of which might have one or more of a series of discrete. values, and might not be capable of continuous variation, or again of a system possessing a large number of discontinuities in the amount of energy which it could contain. It is scarcely probable that the amounts of energy would be proportional to the numbers 1, 2, 3, . . ., but we imagine Planck's assumption is partly justified on the grounds of its simplicity.

Where, as in this case, a method of investigation does necessarily lead to definite conclusions it is important that these conclusions should be worked out, as they must have a disturbing effect on preconceived theories.

(2) In 1909 Prof. Max Planck was invited to give a course of eight lectures at the Columbia College, New York, on the present system of theoretical physics. Under the terms of the Ernest Kempton Adams bequest to Columbia University an English translation of these lectures has now been published, drawn up by Prof. A. P. Wills. It will be seen that the date of these lectures is anterior to Planck's enunciation of his quantum hypothesis, which thus forms no part of their contents.

It is no easy task to give a simple and comprehensive account of such a vast subject in eight lectures, but Prof. Planck's exposition is remarkable for its conciseness, lucidity, and comprehensiveness. As a general survey of the subject the ground covered is best indicated by the titles of the lectures, namely, "Reversibility and Irreversibility," "Thermodynamic States of Equilibrium," "The Atomic Theory of Matter," "Equation of State for a Monatomic Gas," "Heat Radiation, Electrodynamic Theory," "Heat Radiation, Statistical Theory," "General Dynamics, Principle of Least Action," and "Principle of Relativity." We may take the last lecture as a good example of the general character of the book.

Starting with the ordinary notions regarding relative motion of Galileo and Newton, the author first refers to Hertz's theory, and then follows a description of the difficulties introduced by Fizeau's and Michelson and Morley's experiments, both of which lead to the belief that the relative velocity of light is independent of the relative velocity of the ether. The author then shows how these difficulties can be reconciled by the introduction of a new system of space and time co-ordinates for moving bodies which will bring the phenomena attributed to the ether into accordance with the conventional dynamics of material bodies.

The book is one which might with advantage be placed in the hands of a candidate for Honours in physics in one of our universities. To read it cannot fail to be of assistance to a student who has to cover a large amount of work in a limited time. G. H. B.

A CRETACEOUS FLORA.

Catalogue of the Mesozoic Plants in the British Museum (Natural History). The Cretaceous Flora. Part ii., Lower Greensand (Aptian) Plants of Britain. By Dr. Marie C. Stopes. Pp. xxxvi+360+xxxii plates. (London: British Museum (Natural History); Longmans, Green and Co., and others, 1915.) Price 21*s.*

THE Cretaceous Flora, part ii., is devoted to the Lower Greensand (Aptian) flora of Britain. Several species have previously been recorded, but hitherto no general account of the flora as a whole has been written. The most important part of the book is that which deals with new species of Gymnosperms. Twenty-seven Conifers are described, for the most part represented by cones or petrified wood, nine Cycadophyta, five Angiosperms, and two Ferns. The introduction includes some interesting observations on climate, a summary of previous work, and remarks on the geological position of the plant-bearing beds. The descriptions are carefully compiled, and the work of other authors receives frank criticism. A helpful summary is given of current views on the diagnostic value of different anatomical features in the identification of Coniferous wood. The wisdom of employing the generic name Podocarpoxylon for specimens which cannot as a rule be assigned with certainty to the Podocarpineæ is questionable; but Dr. Stopes has, on the whole, adopted a judicial attitude with regard to the taxonomic value of anatomical characters.

One of the most remarkable types is that for which the new generic name Colymbetes is proposed; the type-specimen consists of a piece of well-preserved wood enclosing a large pith surrounded by a broad perimedullary zone; next to this is a ring of bundles of vertical tracheids, succeeded by a series of concentric cylinders of secondary wood, composed alternately of vertical and horizontal elements. It is believed that the alternate cylinders are the products of a single cambium, which, "for some reason unknown, turned at right-angles periodically."

Some new facts are given with regard to *Bennettites Gibsonianus* and other Cycadean plants, and a few new types are described. It is suggested that the formation of more than one cylinder of secondary wood may be accepted as a distinguishing feature of certain Cycadean stems referred to Cycadeoidea, the wood of Bennettites being the product of a single cambium. The con-

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